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Writing Clinical Practice Guidelines in Controlled Natural Language*

Richard N. Shiffman[1], George Michel[1], Michael Krauthammer[1], Norbert E. Fuchs[2], Kaarel Kaljurand[2], and Tobias Kuhn[2]

[1] School of Medicine, Yale University
{richard.shiffman,george.michel,michael.krauthammer}@yale.edu
http://gem.med.yale.edu/ergo/
[2] Department of Informatics and Institute of Computational Linguistics, University of Zurich
{fuchs,kalju,tkuhn}@ifi.uzh.ch
http://attempto.ifi.uzh.ch

Abstract. Clinicians could benefit from decision support systems incorporating the knowledge contained in clinical practice guidelines. However, the unstructured form of these guidelines makes them unsuitable for formal representation. To address this challenge we translated a complete set of pediatric guideline recommendations into Attempto Controlled English (ACE). One experienced pediatrician, one physician and a knowledge engineer assessed that a suitably extended version of ACE can accurately and naturally represent the clinical concepts and the proposed actions of the guidelines. Currently, we are developing a systematic and replicable approach to authoring guideline recommendations in ACE.

1 Introduction

Contemporary healthcare is characterized by widespread practice variation and overuse, underuse, and misuse of medical resources [10–12]. To address these issues, a worldwide initiative to create, disseminate, and implement clinical practice guidelines has arisen.

Clinical practice guidelines are defined as "systematically developed statements to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances" [2]. Modern guidelines help to make explicit the scientific basis for guideline statements. In their most common form, guidelines are documents that contain recommendations that support clinical decision-making by healthcare professionals and patients.

More than 4000 guidelines on hundreds of clinical topics have been published by a wide variety of organizations [3]. These guidelines summarize the most current understanding of what constitutes "best practice".

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[3] http://www.g-i-n.net

Guidelines are developed by teams of medical experts who systematically review and appraise the relevant biomedical literature and apply rigorous methods to link recommendations about appropriate care to the supporting scientific evidence. In general, the development process involves: (1) topic selection, (2) convening a multidisciplinary panel, (3) defining scope and questions to be addressed, (4) searching the biomedical literature for relevant evidence and filtering that evidence to ascertain the most representative and valid subset, (5) evaluating evidence quality and creating evidence tables, (7) developing consensus about appropriate care, (8) formulating recommendation statements and assigning a recommending strength, (9) submitting the draft guideline for peer review, and (10) publishing the final product.

However, guideline development is often handicapped by problems in 5 areas that detract from their use and usability: (1) defects in guideline quality, (2) imprecise guideline language, (3) non-transparent knowledge synthesis, (4) ineffective implementation and uptake, (5) problems formalizing guidelines. We will explore each of these areas of deficiency and then describe an approach to addressing these issues that applies controlled natural language tools.

1.1 Defects in Guideline Quality

A decade ago, Grilli [13] and Shaneyfelt [14] pointed out that guidelines were not adhering to emerging quality standards. Criteria that define valid and useful guidelines have been established and codified in the AGREE instrument [15] and in the Conference on Guidelines Standardization (COGS) statement [16]. Grilli reported that after examining 431 specialty society guidelines, 87% did not report whether a literature search had been done, and 67% did not describe the type of professionals involved in guideline development. Such defects in documentation represent a threat to guideline quality. We propose a tool that incorporates reminders to guideline authors about requisite content and prompts them to document relevant information.

1.2 Imprecise Guideline Language

As early as 1995, Tierney et al. [17] noted that "as written, guidelines are often difficult or impossible to implement". They suggested that authors write recommendations as rules in a simple "If-then-else" format with all the parameters strictly defined. An updated view of this proposal suggests that authors should be explicit about: when(i.e. under what circumstances); who; ought (i.e. at which level of obligation); to do what; to whom; how; why.

Because guideline authors often do not address these questions, guideline language is often vague and underspecified, and sometimes even frankly ambiguous [18]. True ambiguity, i.e. statements that can be interpreted in two or more discrete ways, is rarely intentional. However, vagueness and underspecification are most often introduced when there is insufficient high-quality evidence to support a recommendation. They are also used when the authors are unable to reach consensus, when they have concerns about setting a legal standard of

care, and when economics dictate a course that reflects scarce resources. It would be valuable to implementers if the authors were explicit about the reasons for deliberate vagueness or underspecification.

Experience with the Guidelines Implementability Appraisal indicates that each recommendation must be decidable (i.e., the guideline's intended audience should consistently determine whether each condition in the recommendation has been satisfied), and each recommendation must be executable (i.e. the recommended action should be stated specifically and unambiguously), so that members of the intended audience will execute the recommended action in a consistent way [19]. Yet many current guidelines present statements of fact as "recommendations". For example, a recent guideline on breast cancer management includes the following text as recommendation: "Adjuvant hormone therapy for locally advanced breast cancer results in improved survival in the long term." The statement is not executable as written because it does not indicate under what circumstances, who should do what to whom, how, and with what level of obligation. Such statements of fact cannot be implemented without someone, in many cases the implementer rather than the guideline author, answering these questions.

Additional implementation difficulties are brought about by use of the passive voice, which obscures the actor. Likewise, in recommendations that are aimed at clinicians, statements such as "Patients should receive ..." are unclear about how such an event is to occur. Guidelines should recommend actions that are within the purview of their intended audience.

Another common but troublesome construction is the use of the word "consider" to decrease the level of intended obligation of a verb. It is rarely possible to measure whether an action was "considered". Since guideline recommendations are often intended to be part of quality improvement efforts, the lack of measurability is problematic.

1.3 Deficiencies in Knowledge Synthesis

Guideline authors should explicitly define the quality of evidence that supports recommendation statements and assign a level of recommendation strength. Evidence quality is an indication of the authors' confidence in their appraisal of what benefits and harms can be anticipated if the recommendation is followed [20]. It is based on an analysis of the validity, consistency, and relevance of the scientific evidence supporting a recommendation statement. For example, multiple, well-conducted randomized controlled trials on populations similar to a guideline's target population provide higher confidence than observational studies (cohort and case-control studies). Likewise observational studies provide higher "quality" evidence than case-series and expert consensus. Recommendation strength communicates the authors' assessment of the importance of adhering to the recommendations. It is based on a value judgment about anticipated benefits, risks, harms, and costs associated with adhering to a recommendation, as well as a consideration of evidence quality. Recommendation strength is particularly important to guideline implementers who must design systems that support adher-

ence. Hussain found that less than 41% of randomly selected guideline statements were accompanied by an indicator of recommendation strength [21].

1.4 Ineffective Implementation and Uptake

Balas calculated that only 14% of research findings filter down to everyday practice and that it takes an average of 17 years to do so [22]. This lag in the incorporation of scientific advances into clinical care creates delays that deprive patients of potential health benefits [23]. New evidence alone rarely leads to improvements in practice [24, 25]. Effective mechanisms are needed to influence clinicians to adopt practices based on evidence when such behavior change is justified.

Practice guidelines constitute an important mechanism that can reduce the delivery of inappropriate care and support the introduction of new knowledge into clinical practice [26]. But the knowledge that they contain must be delivered in an effective manner.

Grimshaw and Russell showed that the highest probability of influencing clinician behavior occurs when patient-specific reminders are delivered at the time and place of a consultation [27]. An electronic clinical decision support system (CDSS) is a system that compares patient characteristics with a knowledge base and then guides a health provider by offering patient-specific and situation-specific advice.

1.5 Problems Formalizing Guidelines

There is a mismatch between the unstructured narrative form of published guidelines and the formality that is necessary for the operationalization of guideline knowledge in clinical decision support systems. Uncritical translation of recommendations into computable statements risks distortion of the guideline authors intent. Patel and Ohno-Machado demonstrated that experience and background of knowledge engineers impacts the accuracy of translation [28, 29].

2 Attempto Controlled English (ACE)

In the ERGO Project (Effective Representation of Guidelines with Ontologies) [4] we will demonstrate the feasibility of translating guideline knowledge into rules. We propose to use Attempto Controlled English (ACE) [3] as an intermediate representation between the implicit knowledge contained in the minds of the domain experts and the representation of that knowledge in an explicit computable form.

ACE is a controlled natural language, i.e. a precisely defined subset of English with restrictions on vocabulary and grammar. These restrictions result in increased terminological consistency, reduced ambiguity, consistent vocabulary, potentially templated phrases, and a generally simplified sentence and text

[4] `http://gem.med.yale.edu/ergo/`

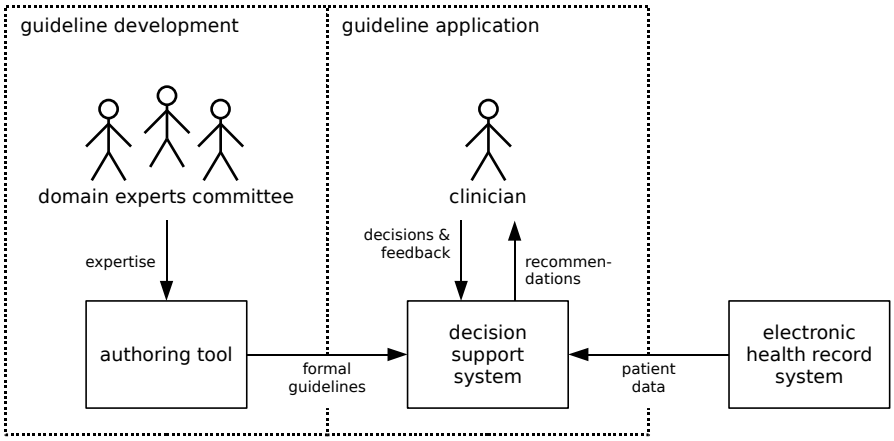

Fig. 1. This diagram shows the general architecture of our approach. It shows the information and data flows between systems (in rectangular shapes) and users. The current focus of the ERGO project lies on the guideline development part.

structure. ACE has the additional benefit of being supported by a parsing engine that translates ACE texts into first-order logic, thus providing a computable format and supporting automatic reasoning. We plan to use ACE to encode the summary recommendation statements that form the backbone of guideline documents. Often published in boldface, these key action statements embody the critical knowledge about appropriate practice that is amplified by supporting text.

Our primary goal is to develop an authoring tool that helps guideline authors to reduce ambiguity, vagueness, incompleteness, and inconsistency, and facilitates the translation of guideline recommendations into logic statements that can be implemented in decision support systems. These systems generally depend on production rules derived from guideline recommendations to create a knowledge base. The decision support system compares an individual patient's characteristics (demographic descriptors and clinical findings) against these rules to guide a health provider by offering patient-specific and situation-specific advice. A second goal is to demonstrate that ACE is a good candidate controlled natural language for writing recommendations. Figure 1 shows the general architecture of our approach.

3 Methods

A critical first step is to establish whether clinical guidelines can be adequately expressed in ACE, and to identify potential barriers to the effective translation of natural language guideline recommendations into controlled natural language.

To answer this question we decided to manually "ACE'ify" the set of recommendations contained in the guideline "Diagnosis, Treatment, and Evaluation of the Initial Urinary Tract Infection in Febrile Infants and Young Children" (UTI) [1].

UTI was chosen because (1) it includes a sufficient number of recommendations to exercise the translation process, (2) its recommendations involve a variety of action types and levels of obligation, (3) some recommendations incorporate a temporal sequence, (4) while others contain sentences related by anaphoric references. In spite of its brevity, this guideline demonstrates many challenges in translating recommendations.

The recommendations were translated by 3 members of the ACE team at the University of Zurich (NEF, TK, KK). They individually created ACE statements for each of the key action statements in the published guideline. Since the goal was to determine feasibility, not reliability, we encouraged independent analysis and translation.

Once translated into ACE, the recommendations were reviewed by a pediatrician with expertise in clinical guidelines (RNS), another physician (MK), and by a knowledge engineer (GM). Judgments were made regarding the accuracy of translation and the naturalness of the ACE statements. Obstacles encountered in the translation process were captured and discussed after all translations were completed.

4 Results

All eleven UTI key action statements were successfully translated into ACE (cf. Appendix). The controlled natural language experts approached the translation problem somewhat differently, but each was able to create rules from each natural language recommendation statement. The rules that they created are interrelated, i.e. they have preconditions that must be fulfilled by other rules, and consequences that can trigger other rules.

As might be expected, there was some level of variability in the ACE translations performed by the 3 ACE experts working independently. Some of the textual variation is of course due to the fact that each rule can only be fully understood in the context of the other rules.

For example, the guideline natural language statement: "Infants and young children 2 months to 2 years of age, including those whose treatment initially was administered parenterally, should complete a 7- to 14-day antimicrobial course orally (Strength of Evidence-Strong)." was transformed into the following statements.

NEF: Every young child must complete an oral antimicrobial-therapy for at least 7 days and at most 14 days.

TK: If the patient is a young child who has a UTI then the doctor must administer an oral antimicrobial-therapy that lasts at least 7 days and that lasts at most 14 days.

Table 1. A comparison of three of the eleven original natural language guidelines together with their ACE equivalents

Original guideline	**Attempto Controlled English**
The presence of UTI should be considered in infants and young children 2 months to 2 years of age with unexplained fever (strength of evidence: strong).	If the patient is a young child who has an unexplained fever then the clinician must consider UTI.
In infants and young children 2 months to 2 years of age with unexplained fever, the degree of toxicity, dehydration, and ability to retain oral intake must be carefully assessed (strength of evidence: strong).	If the patient is a young child who has an unexplained fever then the clinician must assess the degree of Toxicity and must assess the degree of Dehydration and must assess the Ability-to-retain-oral-intake.
If an infant or young child 2 months to 2 years of age with unexplained fever is assessed as being sufficiently ill to warrant immediate antimicrobial therapy, a urine specimen should be obtained by SPA or transurethral bladder catheterization; [...] (strength of evidence: good).	If the patient is a young child who has an unexplained fever and the patient is sufficiently-ill then the clinician should analyze a culture of a urine-specimen that is obtained-by SPA or that is obtained-by Transurethral-catheterization.

KK: Every febrile-young-child that has a UTI must undergo an antimicrobial-therapy that is oral and that lasts at least 7 days and that lasts no more than 14 days.

Table 1 shows three of the original natural language guidelines together with their ACE equivalents.

The pediatrician, the physician and the knowledge engineer concluded that ACE is capable of accurately stating the clinical concepts and the actions described in the guidelines recommendations. ACE statements were judged to be acceptably "natural" sounding by the pediatrician (RNS), a native English speaker.

We interpret the ACE guidelines as forward-chained rules that are executed under the control of the clinician. Every rule consists of preconditions that must be fulfilled to trigger the rule, and conclusions that are true after the rule fired, and that can be used as preconditions for other rules. Execution under the control of the clinician means that after each execution of a rule the clinician decides whether he/she is satisfied with the conclusions found so far, or to execute further rules.

In addition to the guidelines, the experts created a UTI background ontology that included such statements as:

Every child is a person.
SPA is a method.
No analysis confirms X and excludes X.
Every antimicrobial-therapy is a therapy.
...

To get the rule machinery running, a number of initial facts are asserted that originate from the patients electronic health record or that are manually asserted by the clinician, for instance:

The patient is a young child.
The patient's age is 1.5 years.
The patient has an unexplained fever.
...

The complete ACE version of the UTI guidelines is found in the appendix.

5 Obstacles to Translation

Several obstacles were encountered in the course of translation. The means by which each was addressed is described below.

Medical Terminology The ACE vocabulary comprises predefined function words (e.g., determiners, conjunctions, prepositions) and about 100,000 content words (nouns, verbs, adjectives, adverbs). However, specialized medical terminology is not part of the ACE lexicon. Several large standardized vocabularies of medical terms exist, such as UMLS, SNOMED and LOINC. ACE has "hooks" by which external vocabularies can be incorporated. In future work we plan to examine the feasibility of incorporating components of these vocabularies.

Though many of the medical terms can be found in the above mentioned lexicons, the problem remains that terms, such as "ability to retain oral intake", "sufficiently ill" and "SPA", require clear and consistent specifications by guideline authors. We plan to solve this problem by providing an authoring tool that accepts only terms that are known to the system and that have a clearly defined meaning.

It is possible to temporarily add content words to ACE by prefixing unknown words with their respective word-class, for example, v:reevaluate, n:imaging-studies, and a:ill-appearing. Using this approach, it was possible to translate unrecognized medical terms into ACE constructs without using a specialized lexicon.

Level of Obligation Considerable uncertainty accompanies most medical decision making. Variation in evidence validity as well as the accuracy of clinical observations and measurements contribute to this uncertainty.

Guideline recommendations imply a level of obligation. This level is conveyed in two different ways. Specific statements that codify the quality of evidence supporting the recommendation and/or the "strength" of the recommendation accompany many guideline recommendations. In addition, guideline recommendation statements often contain deontic terminology indicated by modal auxilliaries (e.g., "must", "should", "may") or by use of other constructions (e.g., "is appropriate","the Committee strongly recommends").

At the outset of this study, only the modals "can" and "must" were available in ACE. Lomotan and colleagues demonstrated in [30] that these are not sufficient to capture the range of obligations imposed by recommendations. It has already been noted as a Best Practice [5] that a limited vocabulary of "must/required/shall", "should/recommended", and "may/optional" (and their negations) represent a limited vocabulary of keywords for use in Internet Requests for Comments. In guideline recommendations "should" is the most frequently used modal with a level of obligation between "can" and "must". To adequately represent the required levels, ACE was extended by the modals "should/it is recommended that" and "may/it is admissible that", and their negated forms. This is already reflected in the examples of table 1.

6 Discussion and Future Work

In this work, we demonstrated that ACE can be used to express the recommendation statements contained in clinical practice guidelines. These statements express the semantics of the natural language in a format that is suitable for standardization. ACE guideline recommendation statements are natural sounding, yet may be constrained in terms of grammar, vocabulary and style. Furthermore, ACE statements can be translated to discourse representations structures in an automated manner that can be further transformed into computer-interpretable statements.

Now that we have demonstrated feasibility, our immediate plan is to build a "look-ahead" editor for clinical practice guidelines expressed in ACE. This editor is intended for use by guideline authors to remedy the defects in the development process described in the introduction. The editor will incorporate 4 modules:

To improve the comprehensiveness of documentation of the elements necessary to establish guideline validity and facilitate usability, we plan to include a module that prompts authors to include each of the COGS checklist components. In many cases, a guideline authoring group will be able to store standard language that is repeated in each guideline, e.g., how conflicts of interest are handled and the scheme for encoding evidence quality.

To facilitate knowledge synthesis, a module, perhaps configured as a wizard, will lead the developers through a process of recording aggregate evidence quality that supports each recommendation, the benefits, risks, harms, and costs anticipated if the recommendation is carried out, and the judgment of the authors regarding whether there is a preponderance of benefit or harm or an equilibrium between them. That information will be used to define a recommendation strength for each statement. The recommendation strength will dictate and constrain choices for deontic terminology. Strong recommendations will permit use of "must", whereas lower level statements will limit the authors to the use of "should" or "may".

We plan to incorporate a WYSIWYM editor that dynamically displays the knowledge defined so far and the specific options available for extending or revis-

[5] `http://www.faqs.org/rfcs/rfc2119.html`

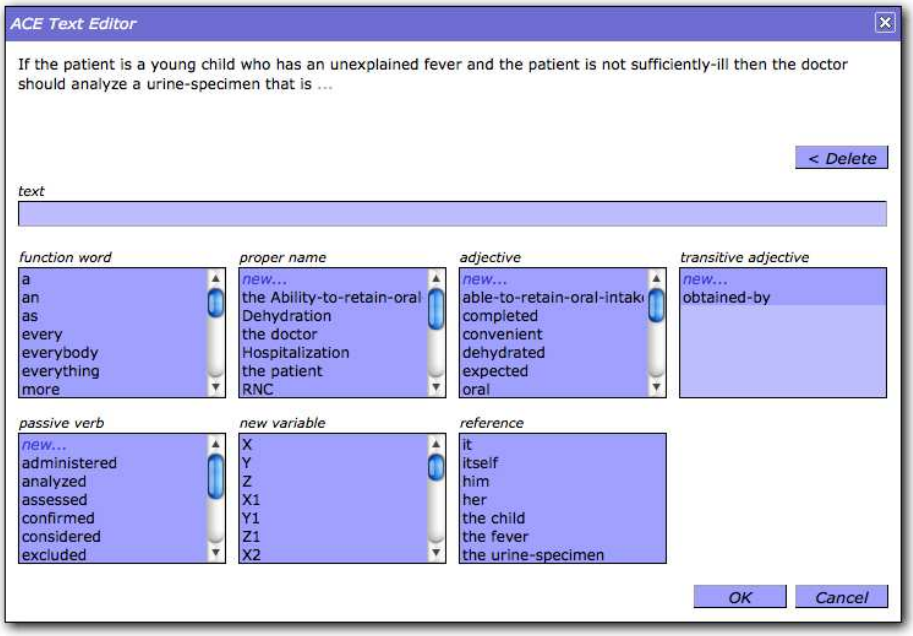

Fig. 2. This screenshot shows Kuhn's ACE Editor adapted to the UTI terminology.

ing it. Such an editor module (similar to the existing ACE Editor [6]) can be used to address the imprecise language that is common in current guideline statements. This approach was described by Scott et al. [6], and has been used by Schwitter [7] and by Kuhn [5] working with controlled language grammars. The editor will constrain authors to write in Attempto Controlled English and can include specific constraints that address identified problems, e.g., flagging the use of the term "consider". Figure 2 shows a screen-shot of Kuhn's ACE Editor, adapted to the terminology of UTI. After the author has entered "If the patient is a young child who has unexplained fever and the patient is not sufficiently-ill then the doctor should analyze a urine-specimen that is", the ACE Editor expects the author to enter the next word from the syntactically possible choices offered by the scroll-menus. Alternatively, the author can freely enter text into the "text" field.

Finally, to diminish the problem of delayed uptake and use of knowledge contained in guidelines, we plan to take advantage of ACE's ability to facilitate translation into computable formats. We will transform the rules that are defined into a standardized computer language (Arden Syntax [31]), and embed these rules within a computer-mediated decision support system. That system will combine the rules with clinical observations about specific patients that are

[6] `http://attempto.ifi.uzh.ch/aceeditor`

derived from an electronic health record system to provide guidance about best practices for care for that patient. As is the case with all decision support applications, the advice provided is advisory and is always presented as such to the users.

7 Appendix: Complete ACE Version of UTI Guidelines

The appendix contains the complete ACE text of the UTI guidelines. The rules derived from the UTI guidelines are designed to be executed under the control of the responsible clinician. If the preconditions of a rule hold then the clinician can decide to "fire" the rule. The consequences of this rule then either confirm/exclude a certain diagnosis or suggest — with various levels of obligation — to perform additional tests. In both cases the clinician decides whether or not to execute further rules.

The different levels of strength of evidence are represented in the following way: "strength of evidence: strong" is represented by the modal verb "must"; "strength of evidence: good" is represented by "should"; "strength of evidence: fair" and "strength of evidence: opinion/consensus" are represented by "can". Note that the modals occur only in the consequences of the rules.

It is assumed that exactly two actors exist: the patient and the doctor. This allows us to simplify the formalization. E.g. instead of "... perform Ultrasonography on the patient", we can just say "... perform Ultrasonography", which implicitly and unambiguously refers to the patient.

There is a small background ontology. Furthermore, there are some auxiliary rules (2.2, 2.3, 2.4, 4.3, 4.4, 4.5, 4.6 and 8.2), which do not explicitly occur in the original guidelines and look somewhat redundant. They are, however, needed to interconnect the rules.

Lines prefixed by "#" are comments that are ignored by the ACE parser.

```
# Background Ontology
# ===================

Every child is a person.
Every infant is a person.
Every infant's age is less than 1 year.
Every person whose age is more than 2 months and
             whose age is less than 2 years is a young child.

SPA is a method.
Transurethral-catheterization is a method.

No analysis confirms X and excludes X.

Every antimicrobial-therapy is a therapy.

Ultrasonography is an imaging-study.
VCUG is an imaging-study.
RNC is an imaging-study.


# Background Rules
# ================

# Rule B.1
```

```
If
   the doctor administers a therapy
then
   the patient undergoes the therapy.

# Rule B.2
If
   the patient undergoes a therapy
then
   the therapy is completed or
   the therapy is not completed.

# Rule B.3
If
   the doctor performs an imaging-study
then
   the imaging-study is completed or
   the imaging-study is not completed.


# Recommendation 1
# ================

# Rule 1.1
If
   the patient is a young child who has an unexplained fever
then
   the doctor must consider UTI.


# Recommendation 2
# ================

# Rule 2.1
If
   the patient is a young child who has an unexplained fever
then
   the doctor must assess the degree of Toxicity and
              must assess the degree of Dehydration and
              must assess the Ability-to-retain-oral-intake.

# Rule 2.2
If
   the doctor assesses the degree of Toxicity
then
   the patient is toxic or
              is not toxic.

# Rule 2.3
If
   the doctor assesses the degree of Dehydration
then
   the patient is dehydrated or
              is not dehydrated.

# Rule 2.4
If
   the doctor assesses the Ability-to-retain-oral-intake
then
   the patient is able-to-retain-oral-intake or
              is not able-to-retain-oral-intake.


# Recommendation 3
# ================

# Rule 3.1
If
```

```
   the patient is a young child who has an unexplained fever and
   the patient is sufficiently-ill
then
   the doctor should analyze a culture of a urine-specimen
      that is obtained-by SPA or
      that is obtained-by Transurethral-catheterization.


# Recommendation 4
# ================

# Rule 4.1
If
   the patient is a young child who has an unexplained fever and
   the patient is not sufficiently-ill
then
   the doctor should analyze a culture of a urine-specimen
      that is obtained-by SPA or
      that is obtained-by Transurethral-catheterization or
      that is obtained-by a convenient method.

# Rule 4.2
If
   the patient is a young child who has an unexplained fever and
   the patient is not sufficiently-ill and
   the doctor analyzes a culture of a urine-specimen
      that is obtained-by a convenient method and
   the analysis of the culture suggests UTI
then
   the doctor should analyze a culture of a urine-specimen
      that is obtained-by SPA or
      that is obtained-by Transurethral-catheterization.

# Rule 4.3
If
   the doctor analyzes a culture of a urine-specimen
      that is obtained-by SPA or
      that is obtained-by Transurethral-catheterization
then
   the analysis of the culture confirms UTI or
                               excludes UTI.

# Rule 4.4
If
   the doctor analyzes a culture of a urine-specimen that is obtained-by a convenient method
then
   the analysis of the culture suggests UTI or
                               does not suggest UTI.

# Rule 4.5
If
   the analysis of a culture of a urine-specimen confirms UTI
then
   the patient has UTI.

# Rule 4.6
If
   the analysis of a culture of a urine-specimen excludes UTI
then
   the patient does not have UTI.


# Recommendation 5
# ================
#
# Recommendation 5 is integrated into the recommendations 3 and 4.
```

```
# Recommendation 6
# ================

# Rule 6.1
If
   the patient is a young child who has an unexplained fever, and
   the patient is toxic or
               is dehydrated or
               is not able-to-retain-oral-intake
then
   the doctor can administer an antimicrobial-therapy and
               can consider Hospitalization.


# Recommendation 7
# ================

# Rule 7.1
If
   the patient is a young child and
   the analysis of a culture of a urine-specimen confirms UTI
then
   the doctor should administer a parenteral antimicrobial-therapy or
               should administer an oral antimicrobial-therapy.


# Recommendation 8
# ================

# Rule 8.1
If
   the patient is a young child who has UTI and
   the patient undergoes an antimicrobial-therapy for 2 days and
               does not show the expected response of the antimicrobial-therapy
then
   the doctor should reevaluate the patient and
               should analyze a culture of a second urine-specimen.

# Rule 8.2
If
   the patient is a young child who has UTI and
   the patient undergoes an antimicrobial-therapy for 2 days
then
   the patient shows the expected response of the antimicrobial-therapy or
               does not show the expected response of the antimicrobial-therapy.


# Recommendation 9
# ================

# Rule 9.1
If
   the patient is a young child who has UTI
then
   the doctor must administer an oral antimicrobial-therapy that lasts at least 7 days and
                                                                that lasts at most 14 days.


# Recommendation 10
# =================

# Rule 10.1
If
   the patient is a young child who has UTI and
   the antimicrobial-therapy of the patient is completed and
   the imaging-study of the patient is not completed
then
   the doctor should administer a therapeutically-dosed antimicrobial or
```

```
            should administer a prophylactically-dosed antimicrobial.

# Recommendation 11
# =================

# Rule 11.1
If
   the patient is a young child who has UTI and
   the patient undergoes an antimicrobial-therapy for 2 days and
               does not show the expected response of the antimicrobial-therapy
then
   the doctor can perform Ultrasonography promptly, and
   the doctor can perform VCUG or
               can perform RNC.

# Rule 11.2
If
   the patient is a young child who has UTI and
   the patient undergoes an antimicrobial-therapy for 2 days and
               shows the expected response of the antimicrobial-therapy
then
   the doctor can perform Ultrasonography, and
   the doctor can perform VCUG or
               can perform RNC.
```

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